MINISTRY OF NATURAL RESOURCES AND CLIMATE CHANGE

DEPARTMENT OF CLIMATE CHANGE AND METEOROLOGICAL SERVICES

Climate Risk Maps
Nsanje District

December 2022

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1. Introduction

a. Geography

Located in the southern tip of Malawi Nsanje district covers 1,942 square kilometres and has a population of 299,168 (National Statistical Office, 2019) that spread in 9 traditional authorities (TAs). From the Northern side of the district, the TAs are Mlolo which has a total population of 69,110; SC Mbenje 53,559; Tengani 41,100; Malemia 22,437; Ngabu 13,381; Makoko 10,335; Chimombo 26,844; Nyachikadza 7,643; Ndamera 33,679; Mwabvi Game Reserve 8,746 and Nsanje Boma 26,844. Nsanje District is in the Shire River Valley and the altitude ranges from 61 to the eastern part of the district to 610 meters above sea level to the west. Fig.1. The Mwabvi Game reserve lies to the North-western side of the district.

The main crops that are grown in Nsanje District are maize, millet, sorghum, rice, sweet potatoes, beans and cotton. Most of the farming activities rely on rain during summer while winter cultivation is largely based on irrigation along the main rivers in the district. Nsanje district has a lot of livestock such as cattle, goats, sheep and chickens, Fishing is also dominant on Shire River.

b. Climate and common hazards in Nsanje District

The climate in Nsanje district is mainly hot where the maximum temperatures go beyond 40 degrees Celsius in summer and minimums of around 18 degrees in winter. The annual rainfall is less than 800mm. Nsanje is prone to both floods and droughts/dry spells and some of the worst floods occurred in January 2015, May 2019, January 2022 and March 2022. Nsanje district was the most affected district in Malawi where the damage was 16.5% of the total national loss of MWK 145,563 million (USD 335milion) during the 2015 floods (GOM, 2015). The recovery and reconstruction needs were estimated at US$7.3 million (~ MWK 7,491,296,500) (GOM, 2015). The 2019 floods were also of the similar magnitude as 2015 in Nsanje district (GOM, 2019). The district is also prone to recurrent pests that destroy crops. These pests often come during prolonged dry spells. Strong winds that damage buildings and crops are also common in the district.

c. Objective of the study

The objective of this project is to develop the climate risk maps for Nsanje District. The climate risk maps in this study cover extreme rainfall, rainfall trend, heatwaves (extreme maximum and minimum temperature), dry spells, drought events and floods. Due to unavailability of daily maximum wind speed, the maps of wind hazard are not generated. The

production is made based on 1981 to 2020 period.

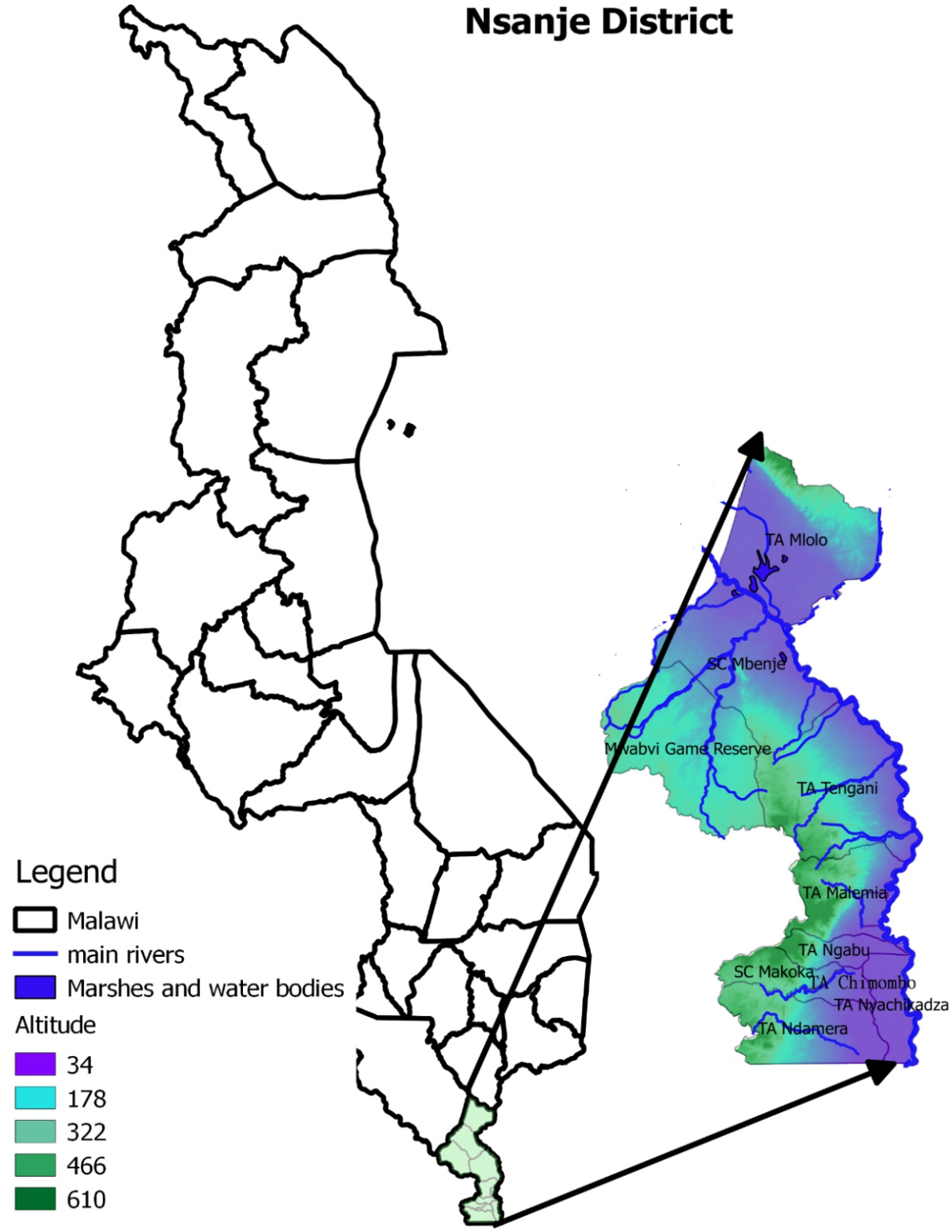

Figure 1 Nsanje District, traditional authorities (TAs), main rivers and topography

d. Methods

The development of risk maps follows the definition below, where the **Risk** is the product of **Likelihood** and **Impact.**

Risk = Likelihood X Impact

Therefore, the analysis involves the estimation of likelihood and impact in order to generate the risk of dry spells, droughts and floods. The classification of likelihood, impact and risk as used in this project are presented in Table 1 below.

Table 1 The Classification of Likelihood, Impact and Risk by colour

Likelihood	Impact	Risk
improbable	negligible	negligible
remote	low	low
occasional	moderate	medium
probable	significant	high
frequent	catastrophic	extremely high

2. Climate Risk Maps

a. Rainfall trend

There is a general increasing trend of rainfall in Nsanje district over many places though the increase is not significant except Makhanga in TA Mlolo. However, the southern part of the district has negative trend which is significant at Msilaga in TA Makoko. Considering the whole district, rainfall is increasing in Nsanje district but the increase is not significant, Fig. 2.

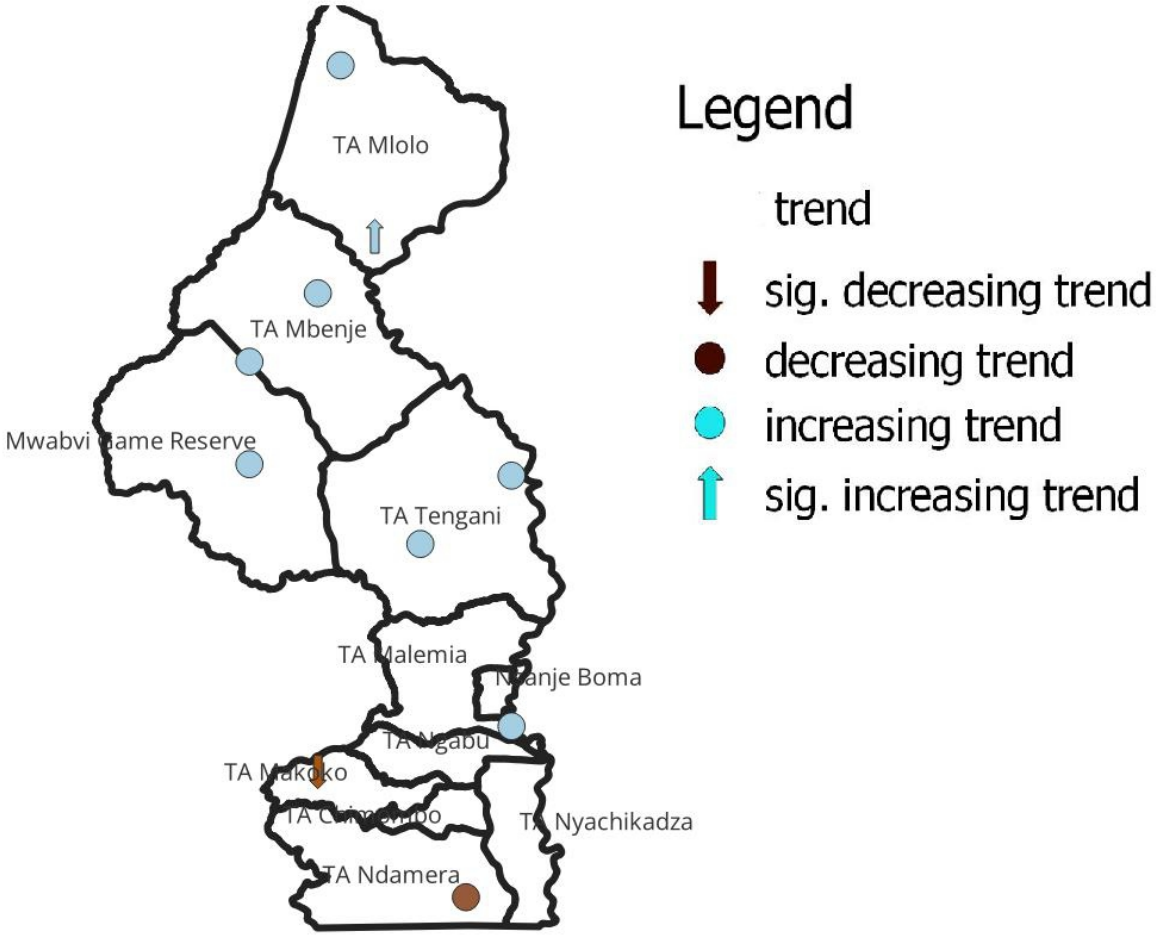

Figure 2 Rainfall trend in Nsanje District. The significance of the trends is based on p-value < 0.05

b. Extreme rainfall

Despite that Nsanje receives less annual rainfall, the maximum absolute rainfall (highest recorded in 24 hours) ranges from 110 in TAs Ndamera, Chimombo, Makoko, Ngabu, part of TA Mlolo and part of Mwabvi Game Reserve to 310 mm in TA Tengani and southern TA Mlolo, Fig.3. All this indicates the possibility of the district to receive rainfall exceeding 100mm in 24 hours in the district.

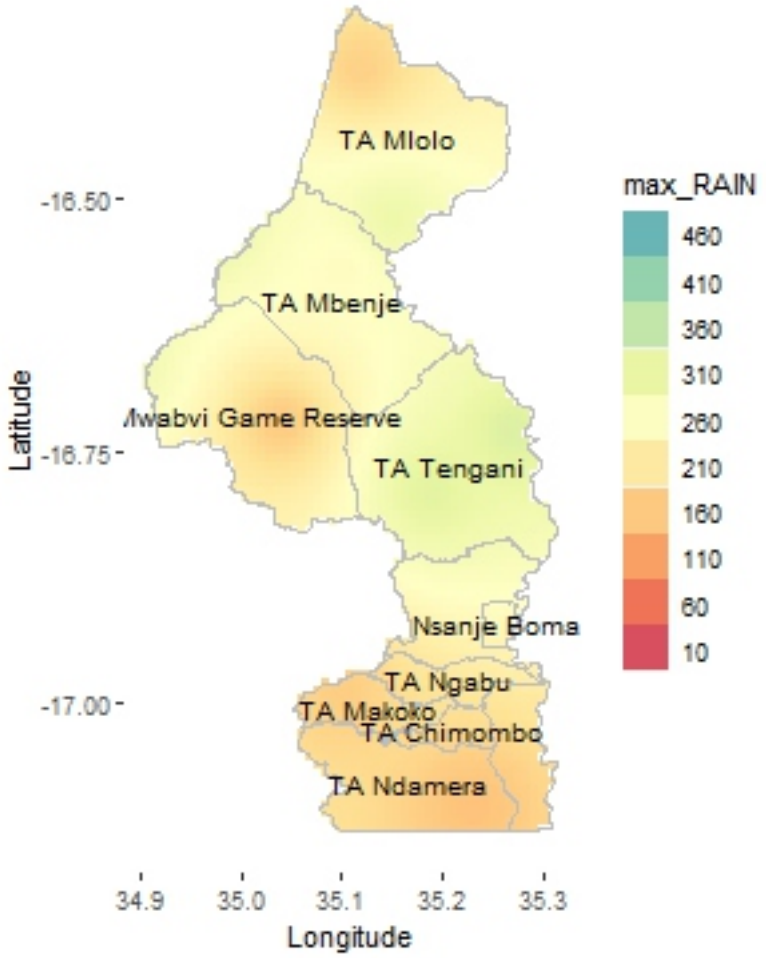

Figure 3 Absolute maximum rainfall in Nsanje district

c. Heatwaves (high temperatures)

The extreme heatwaves are likely in Mwabvi Game Reserve that extend into neighbouring TAs of Mbenje and Tengani, Fig.4, where the diurnal range of temperature is also low. However, the rest of the district is prone to severe heat waves. The temperature diurnal range is lowest in TA Ndamera and Nyachikadza.

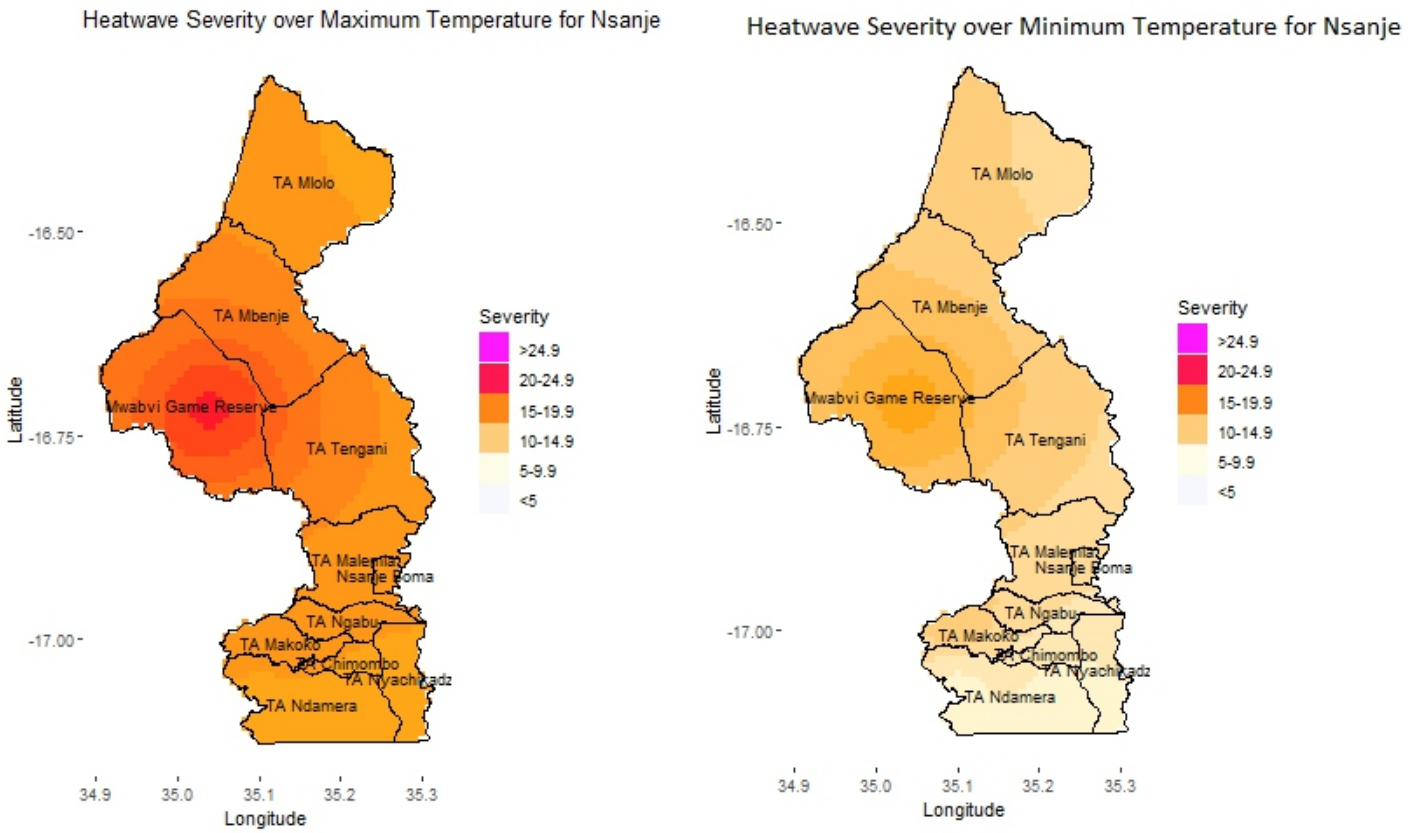

Figure 4 The heatwave based on maximum temperature (left) and minimum temperature (right)

d. Dry spells

i. Frequency of dry spells at the beginning of the season

The dry spells at the beginning of rainfall season are presented in Fig. 5. The beginning of the season in this study refers to October-November-December (OND) and the Fig. (5a) is the frequency of the dry spells of more than 7 days and (5b) is the frequency of dry spells of more than 14 days from 1981 to 2020 in Nsanje district.

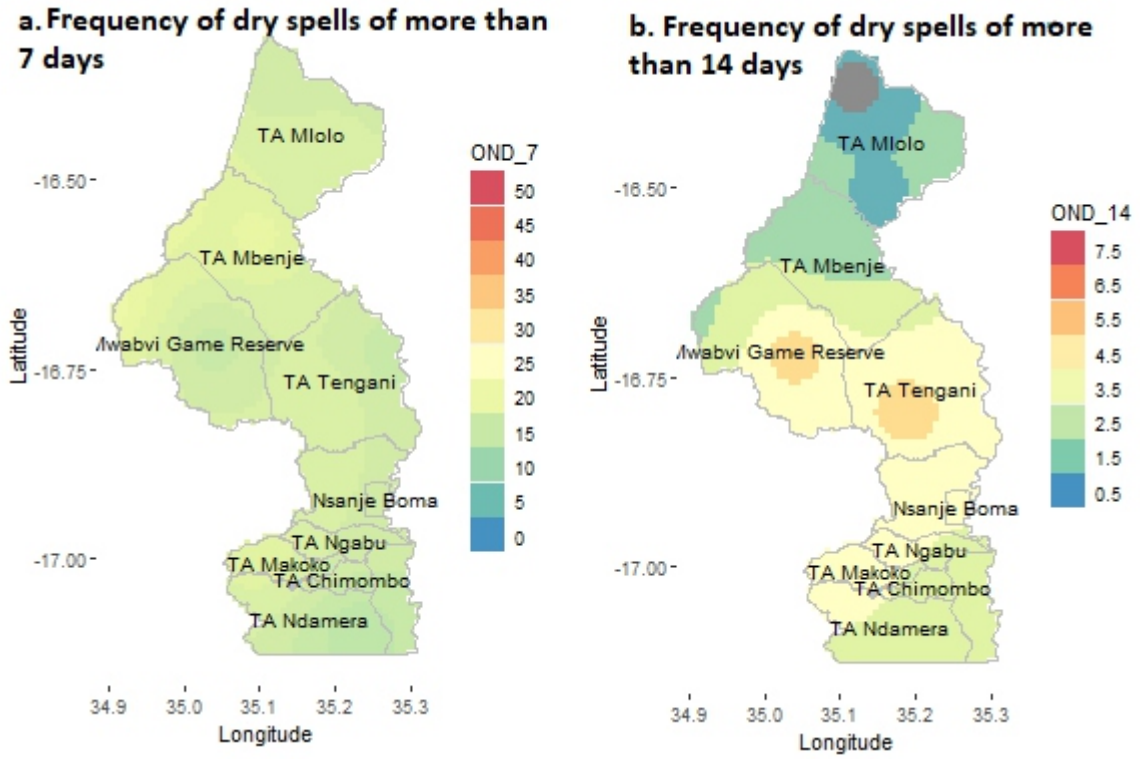

Figure 5 The frequency of dry spells of more than 7 days (a) and more than 14 days (b) in Nsanje district

The dry spells that are more than 7 consecutive days at the beginning of rainfall season in October-November-December (OND) are common in Nsanje district (Fig. 5a). The frequency of these dry spells ranges from 15 to 20 times between 1981 to 2020 which is the probability between 40 to 53%. The frequency of prolonged dry spells beyond 14 days at the beginning of rainfall season is highest in TA Tengani and Mwabvi Game Reserve, where the frequency ranges from 5 (13% probability) to 6 (16% probability) times, while Nsanje Boma, TA Malemia, TA Ngabu, TA Makoko, TA Chimimbo and TA Ndamera the frequency is below 5 times (13% probability). Prolonged dry spells at the beginning of rainfall season are less common in TA Mlolo, Fig. 5b.

ii. Frequency of dry spells during the season

The dry spells are also common during the rainfall season from January all the way to March. The frequency of 7-day dry spells ranges from 21 to 27 times (55 to 71% probability) in January, 20 to 25 times (53 to 66%) in February and 37 times (97%) in March (Fig. 6-Upper panel). March has the worst dry spells but probably is also due to the fact that March is the beginning of the cessation of rainfall season. The less frequent dry spells are in TA Chimombo and Nyachikadza for 7-day dry spells (Fig 6-Upper panel). The 14-day dry spells in Nsanje are also worse in March compared to January and February (Fig. 6-Lower panel), where the frequency ranges from 11 to 15 times (29 to 39% probability) and the worst hit TAs

are those located in the Southern Nsanje such as Ndamera, Nyachikaza, Chimombo, Ngabu, Makoko, Tengani and Malemia. In February, the highest frequency for dry spells is also the southern TAs of Ndamera, Nyachikaza, Chimombo, Ngabu, Makoko and Malemia where the frequency is up to 10 times (26% probability). The least frequent dry spells are in TA Tengani with only 2 events (5% probability) from 1981 to 2020. The hotspots of dry spells in January are in TA Makoko up to 10 times (26% probability), otherwise the rest of the district has the frequency that ranges from 8 (21% probability) in TA Mbenje to 1 (3%) in TA Ndamera. It is also noted that January is the least affected by prolonged dry spells in Nsanje District

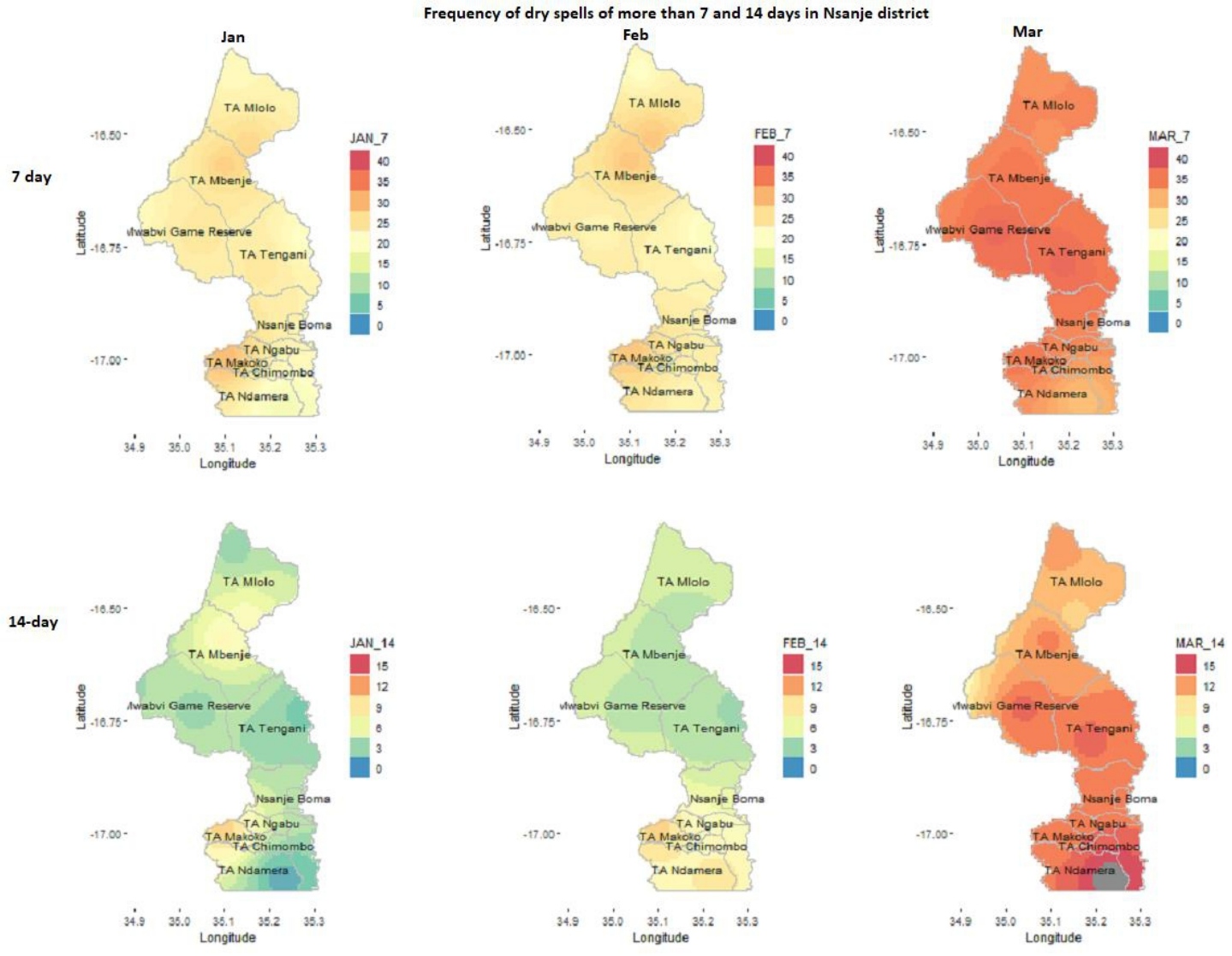

Figure 6 The 7-day (upper panel) and 14-day (lower panel) dry spells in January, February and March in Nsanje district

iii. Dry spell likelihood, impact and risk maps

The likelihood, impact and risk of 7-day and 14-day dry spells combined throughout the rainfall season are presented in Fig. 7. The spatial distribution is uniform across all the TAs

in the district. The 7-day dry spells are frequent on likelihood scale in Nsanje District, Fig. 7 upper-panel (left). However, the impact is moderate on impact scale (Fig. 6 upper-panel (middle)), resulting into high-risk, (Fig. 6 upper-panel (right)).

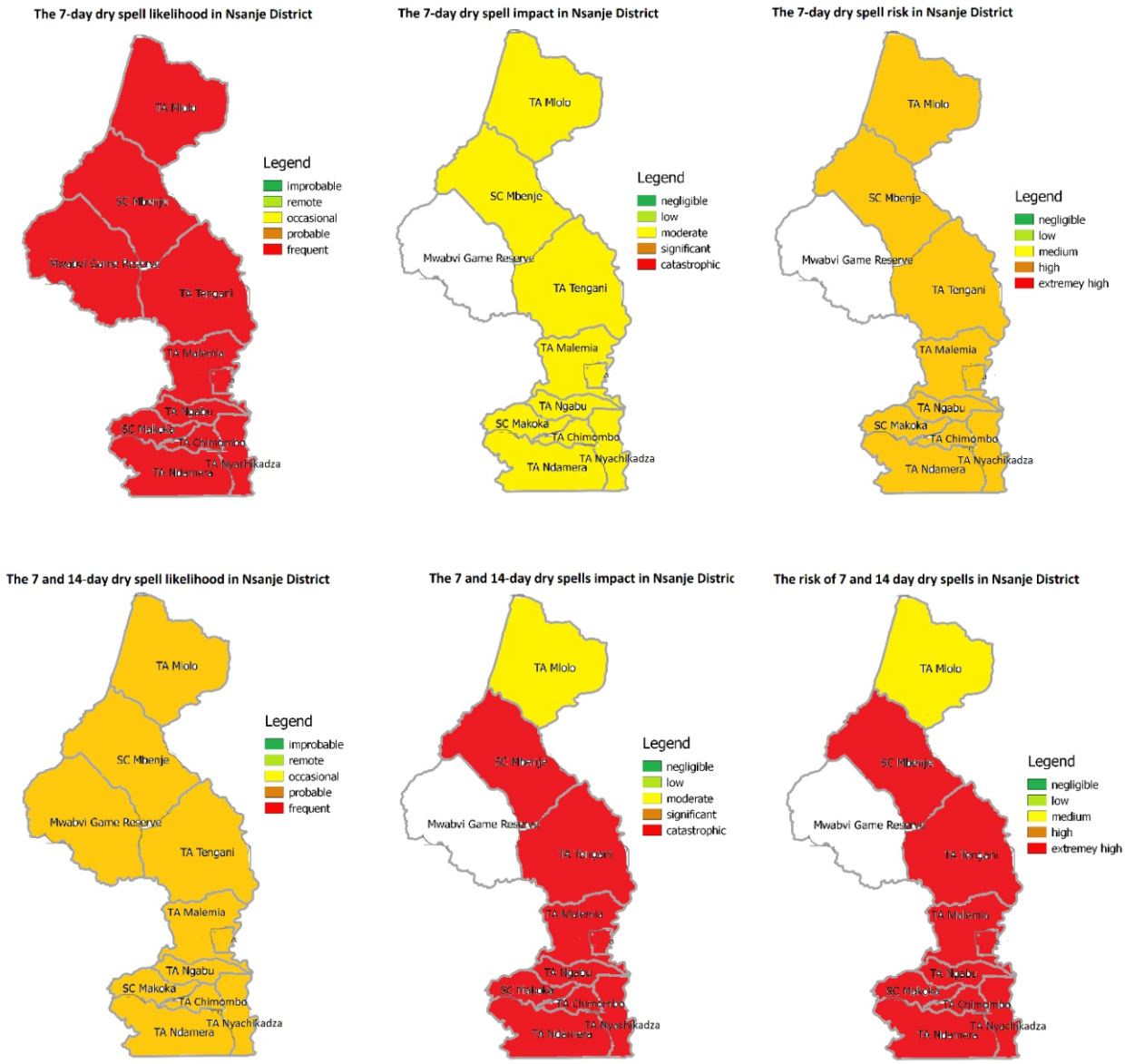

Figure 7 The overall likelihood, impact and risk of dry spells (from left to right respectively) per TA. Upper panel is for the 7-day dry spells and Lower panel is for the combination of 7- and 14-day dry spells. The impact of dry spells is estimated based on the proportion of people affected. So Mwabvi Game Reserve is not included in impact analysis since very few people live in the reserve. The scales are explained in section 1d.

While the overall (7-day and 14-day dry spells combined) dry spell likelihood is probable in the whole Nsanje District (Fig. 7 lower-panel (left)). The combined impact is catastrophic in all the TAs except TA Mlolo which is moderate (Fig. 6 lower-panel (middle)). The impact has risen from moderate for 7-day dry spells to catastrophic indicating that 14-day dry spells have

a higher impact. The overall risk of dry spell is extremely high in all the TA except TA Mlolo which is medium (Fig. 6 lower-panel (right)).

e. Drought events

Very often the dry spells (ng'amba) are mixed with droughts (chilala). However, dry spells are simply a number of successive days without rainfall and this does not take into consideration the amount of rain an area received. It is possible to have a drought without significant dry spells as drought considers the cumulative amount of rainfall acquired in combination with other climatic factors. In this analysis, standardised precipitation and evaporation index (SPEI) is used as the indicator of drought at a 3-month period. SPEI is opted against standardised precipitation index (SPI) because it includes temperature (proxy to evapotranspiration) which is also a very important parameter in drought dynamics.

The project adopts the classification of drought based on Mtilatila et al (2020) as shown in Table 2. The moderately dry $-1 \leq SPEI \leq -1.49$ is defined as moderate drought, severely dry $-1.5 \leq SPEI \leq -1.99$ is a severe drought and extremely dry $SPEI \leq -2$ is an extreme drought.

Table 2 Modified drought classification. Source: Mtilatila et al (2020)

SPEI value	Explanation	Drought intensity
-0.99 to 0.99	Near normal	No drought
-1.0 to -1.49	Moderately dry	Moderate drought
-1.5 to -1.99	Severely dry	Severe drought
< -2	Extremely dry	Extreme drought

Fig. 8 are the timeseries of drought events at various locations in the district from 1982 to 2020. The drought events (red) range from 23 at Bangula and Mwabvi Game reserve to 25 at Nsanje and Makhanga. On average the drought events are severe and last between 5 and 7 months. Though some extreme drought events also exist that can get up to 30 months (e.g., at Bangula there is drought episode that started in May 2015 ended in October 2017 (Fig. 8)).

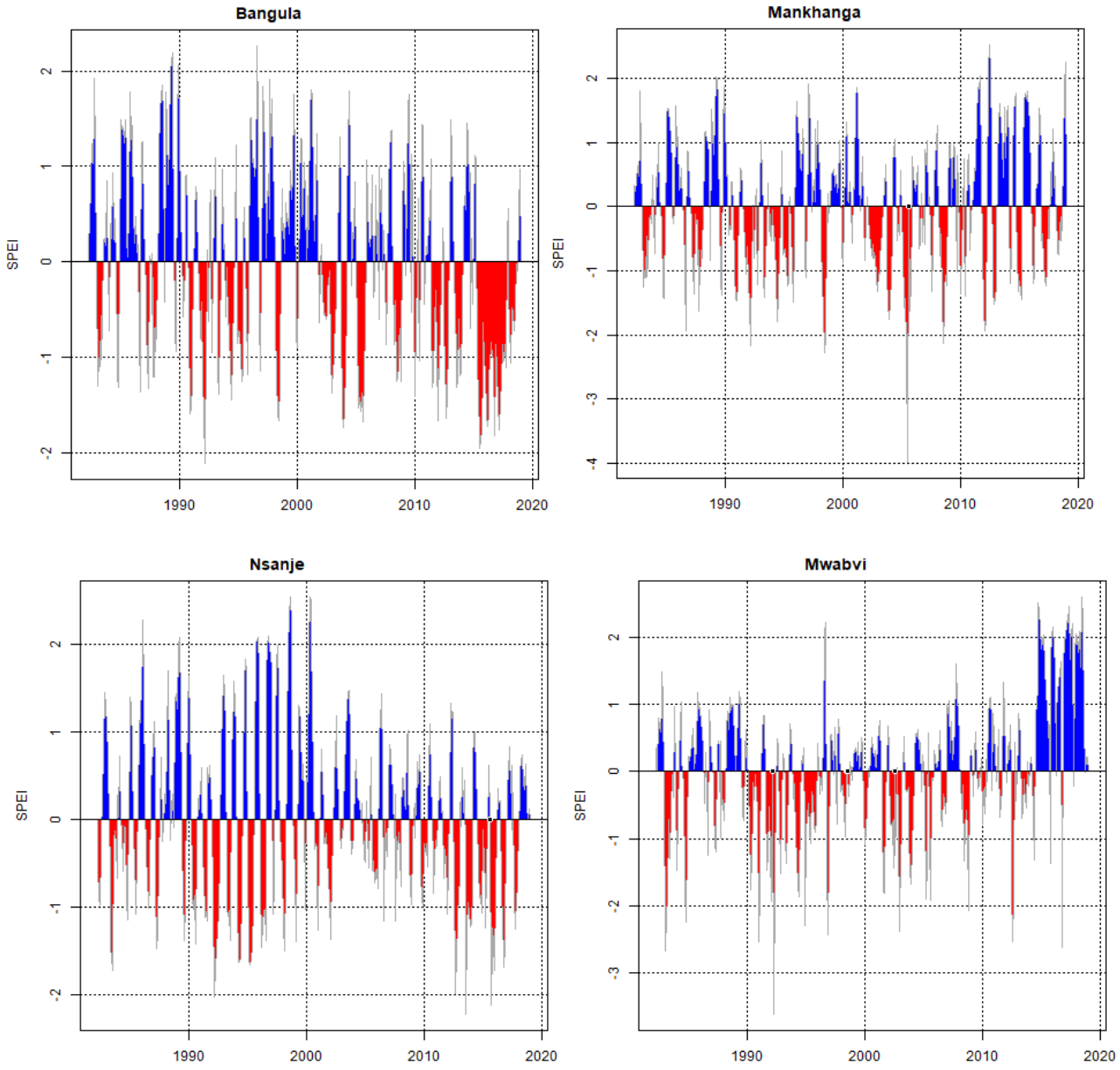

Figure 8 The drought timeseries (red) from 1982 to 2020 at Bangula (upper-left), Makhanga (upper-right), Nsanje (lower-left) and Mwabvi Game Reserve (lower-right). The drought starts when SPEI<-1 and ends when SPET>0.

In space (Fig. 9), the drought events range from 23 to 27 (61 to 71% probability) in Nsanje district (Fig. 9 (left)) with the duration of 5 and 7 months on average (Fig. 9 (middle)) per event. Shorter duration droughts are generally in TA Mlolo while longer drought events are experienced in TAs Ndamera and Makoko. Though the duration is longest in TA Ndamera and Makoko, the intensity is lower (moderate) compared to the rest of the district which on average gets severe droughts (Fig. 9 (right)). In summary, it also shows that drought intensity is significantly increasing in the district (Fig.10) as shown at the nine locations sampled in the district.

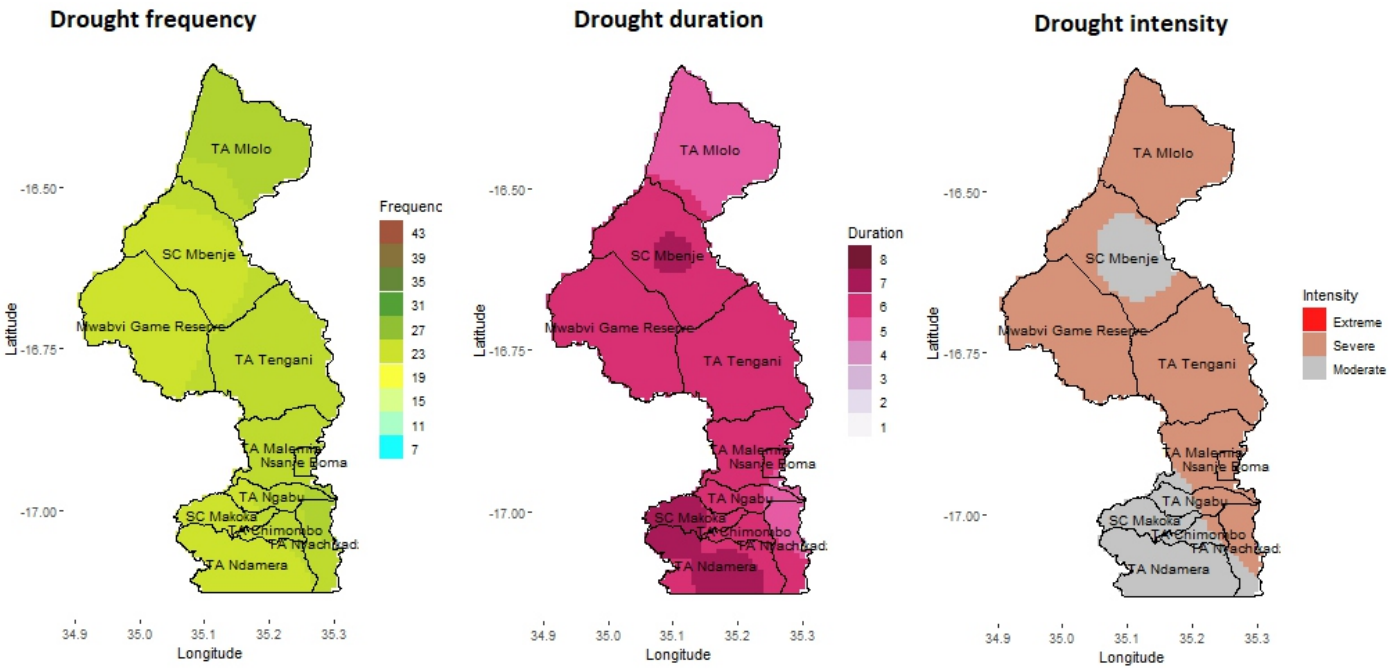

Figure 9 Drought frequency (number of drought events, left), duration (months, middle) and intensity (right)

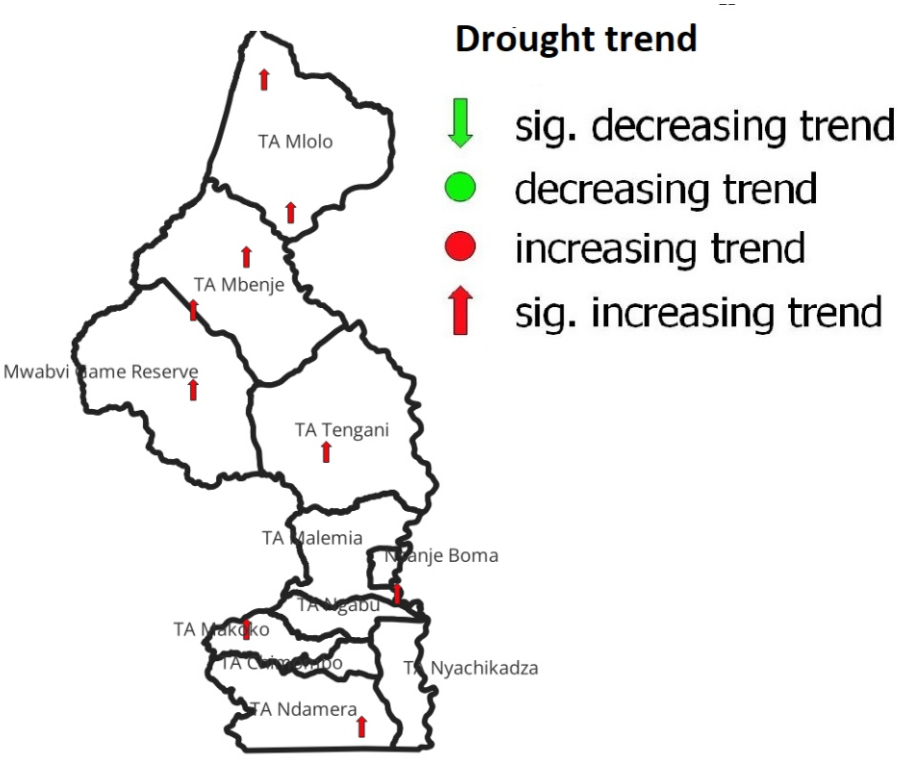

Figure 10 Drought trend in Nsanje district sampled at selected locations. The significance of the trends is based on p-value < 0.05

The probability of the occurrence of drought in Nsanje district ranges from 61 to 71% (frequent in likelihood scale) (Fig. 11 (left)) while the impact is lowest in TA Ndamera and Makoko (moderate), and significant in the rest of the TAs (Fig. 11 (middle)). The end result product is

the high drought risk in TA Makoko and Ndamera while the rest of the district is ranked at extremely high-risk, Fig. 11 (right).

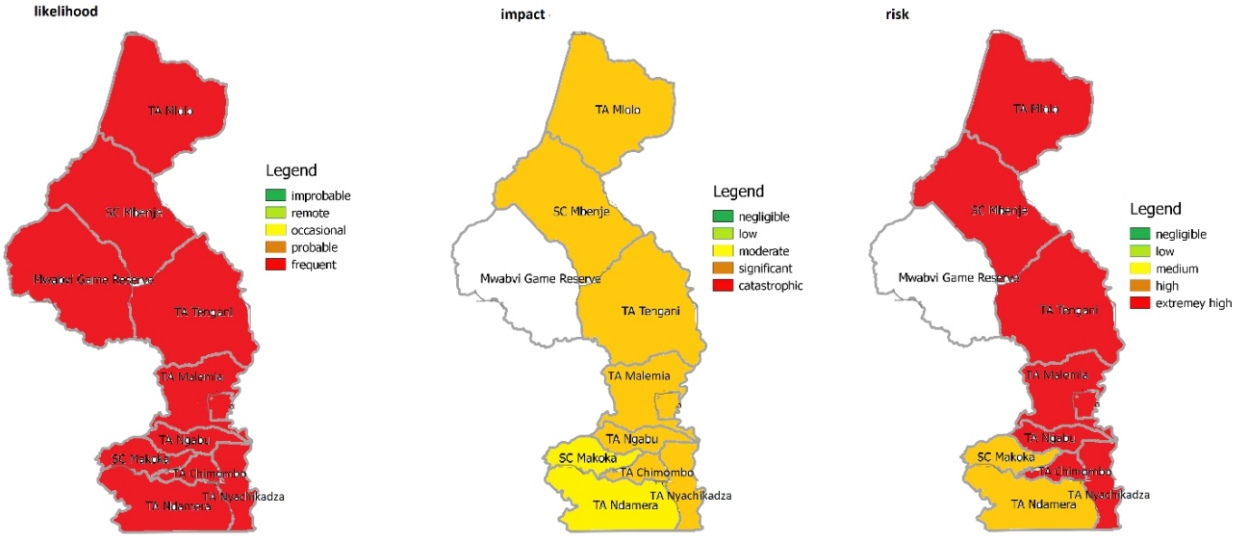

Figure 11 The likelihood, impact and risk of drought (from left to right respectively) per TA. The impact of droughts is estimated based on the proportion of people affected. The scales are explained in Section 1d.

f. Flood maps

The likely flood prone areas are presented in Fig. 12. TA Nyachikadza is very likely to flood, while in TA Mlolo, Mbenje and Chimombo the flood prone areas are almost three-quarter of the total area. The area likely to flood in the rest of the TAs is less than half of the total area.

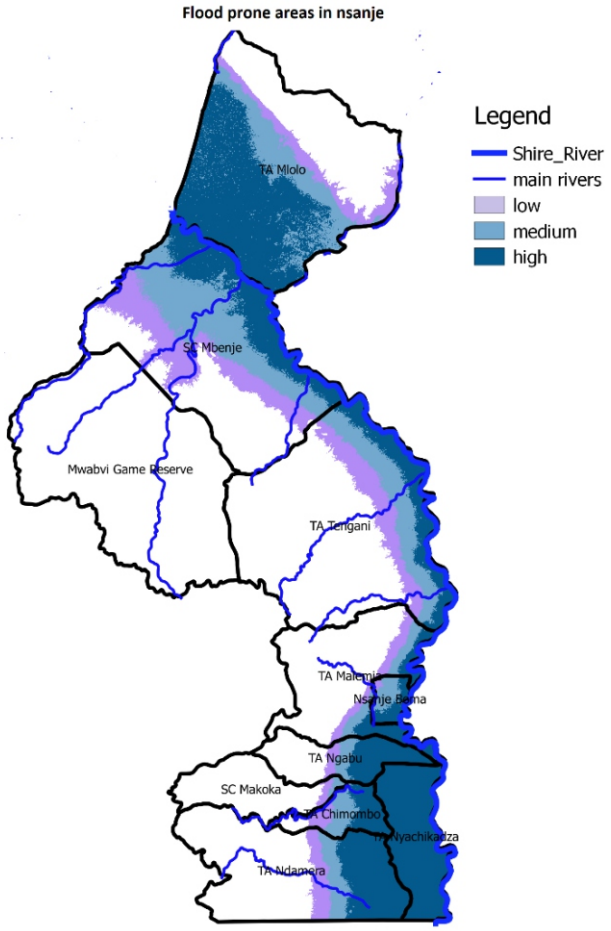

Figure 12 Flood prone areas in Nsanje district

The flood probability, impact and risk are calculated based on the frequency of flood episodes from 1981 to 2020 as well as the proportion of people affected by TA, Fig. 13. The analysis is based on the data from the Department of Disaster Management Affairs.

The likelihood of floods is lowest in TA Makoko and highest in TA Mlolo, Mbenje, Nyachikadza and Tengani where they are most frequent. The probability of occurrence is probable in TA Ngabu and occasional in TAs Malemia, Chimombo and Ndamera, Fig.13 (left).

The impact of the flood is only significant if it affects people. Therefore, the impact is based on the proportion of people affected in relation to the total population in the same TA. Therefore, the impact of floods is lowest in TA Makoko, followed by Tengani and Malemia. Otherwise, the impact is moderate in TAs Mlolo, Mbenje and Ndamera, and significant in TA Ngabu. The worst impacts are in TAs Chimombo and Nyachikadza, Fig. 13 (middle). The risk therefore, is extremely high in TAs Ngabu and Nyachikadza; high in TA mlolo, Mbenje and Chimombo; medium in TA Tengani, TA Ndamera; low in TA Malemia; and negligible in TA Makoko Fig. 13 (right).

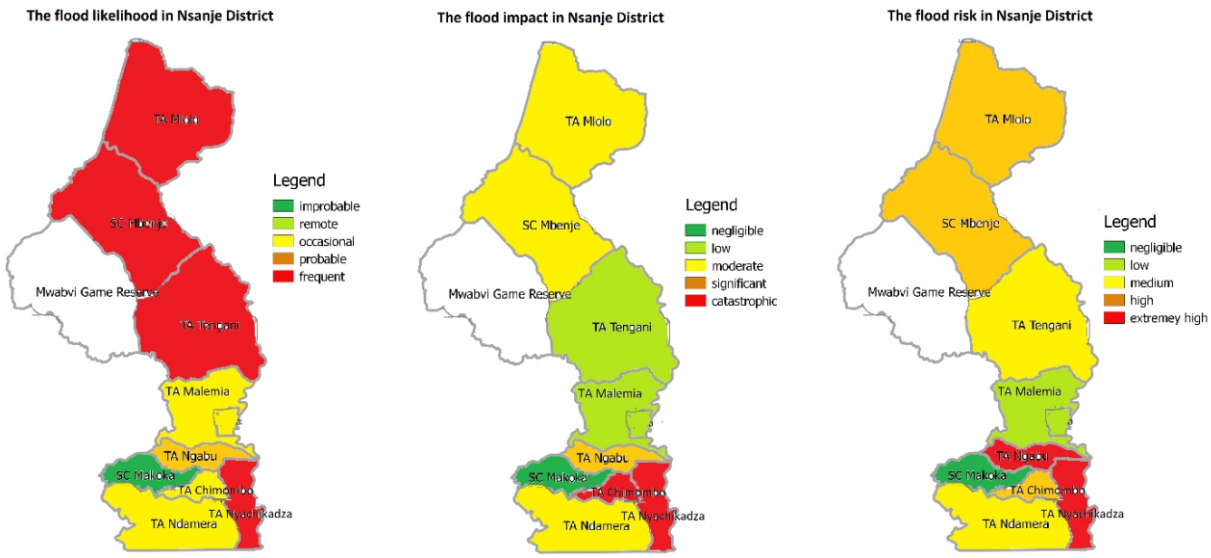

Figure 13 The likelihood, impact and risk of floods (from left to right respectively) per TA. The impact of floods is estimated based on the proportion of people affected. The scales are explained in Section 1d.

g. Overall climate risk

Fig. 14 is summarising the dry spell, drought and flood risk in Nsanje district. TAs Mlolo, Mbenje, Ngabu, Chimombo, Nyachikadza and Tengani are at extremely high-risk, followed by TA Ndamera and Malemia, while TA Makoko is at medium-risk. Table 3 is ranking the TAs from the most vulnerable TA to least vulnerable. TAs Nyachikadza and Ngabu are at extremely high-risk because of all the three hazards; dry spells, droughts and floods, Tab. 3. While TAs Chimombo and Mbenje have extremely high-risk in both droughts and dry spells but high-risk on floods. The next TA is Tengani with extremely high-risk in dry spells and droughts but medium for floods. TA Mlolo has an extremely high-risk of droughts, high-risk on floods and medium-risk on dry spells. TA Malemia is at extremely high-risk of both dry spells and droughts but low-risk for floods. TA Ndamera has an extremely high-risk of dry spells, high-risk on droughts and medium-risk of floods. The last one is TA Makoko that has extremely high-risk on dry spells, high-risk on droughts but negligible risk on floods.

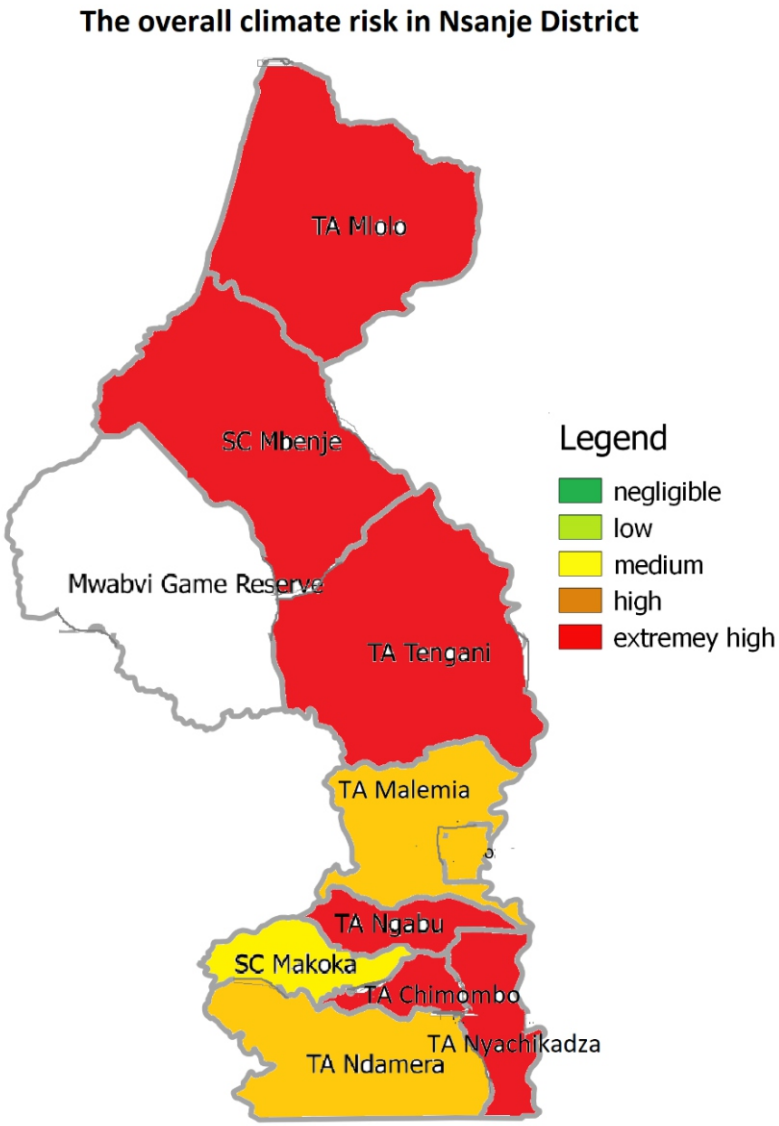

Figure 14 Overall climate risk in Nsanje district per TA (summary of dry spells, drought and floods)

Table 3 The Traditional Authority ranking based on the dry spell, drought and flood risks. The Risk scale is as defined in Section 1d

Rank	TA	Dry spells	Droughts	Floods	Overall
1	Nyachikadza	Extremely high	Extremely high	Extremely high	Extremely high
2	Ngabu	Extremely high	Extremely high	Extremely high	Extremely high
3	Chimombo	Extremely high	Extremely high	High	Extremely high
4	Mbenje	Extremely high	Extremely high	High	Extremely high
5	Tengani	Extremely high	Extremely high	Medium	Extremely high
6	Mlolo	Medium	Extremely high	High	Extremely high
7	Malemia	Extremely high	Extremely high	Low	High
8	Ndamera	Extremely high	High	Medium	High
9	Makoko	Extremely high	High	Negligible	Medium

3. Conclusion

The objective of the study was to delineate the climate risk hot spots in Nsanje District. The analysis has looked at absolute rainfall, heatwaves, dry spells, drought events and floods. The risk maps of each hazard are presented. The overall summary is that most of the TAs in Nsanje are prone to dry spells, heatwaves, droughts and floods. Six out of nine TAs are highly vulnerable to droughts, dry spells and floods. The worst TAs are TAs Nyachikadza and Ngabu. Climate change adaptation and measures to reduce the impacts of these climate hazards is paramount in Nsanje district.

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5. Acknowledgement

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